Integrated Greenhouse gas emission from paddy fields in China

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A Great Challenge to Solve Nitrogen Pollution from Intensive Agriculture

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The huge population and the small arable land area per person determine that intensive agriculture, which is characterized by high ratio of cultivated land to territory, high multiple cropping indices, and large input of agro-chemicals, is an inevitable choice for food security in China. Although the researches were continuously strenthened for good management practices for raising nitrogen use efficiency (NUE), minimizing N losses from croplands, and thus mitigating adverse impacts of N application on environment and the knowledge on rational application of N fertilizers was improved greatly in China in the last three decades, the total consumption of N fertilizers continuously increased and NUE, on the national average, decreased from about 30-35% in 1980s to around 20-30% in 2000s. This is because the top priority for food security drove the increase in consumption of N fertilizers, thus leading to the decrease in NUE. The driving force for producing food as much as possible will continue and potential is available for enhancing crop production through raising multiple cropping indices and increasing N application in China, while, the NUE is unlikely to reach the levels achieved in some developed countries because it decreases with the increases in multiple cropping indices and nitrogen application rate. All of these factors determines that the N consumption will increase in China in future. Therefore, while we should continue to struggling for higher NUE, we have to realize that nitrogen pollution from crop production could not be controlled by raising NUE alone under intensive agriculture. In order to protect our environment and sustain development, we have to face a challenge to solve nitrogen pollution under the condition of high nitrogen application rate. Research should be strengthened for the control of nitrogen pollution through establishedment of theories, principles, technologies, and policies under the intensive agriculture.

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Rice is the crop with the biggest production in China, but the sowing area of rice showed a declining trend since middle 1970s and was outweighed by maize in 2007. The current sowing area is about 29 million ha, with half being single rice, one quarter being early rice and remaining being late rice. Methane (CH_4) emission has been measured on over 30 sites, with varying duration since late 1980s. Measured seasonal emissions were extremely variable, ranging from 3.4 to 1274 kg CH_4 ha^{-1}. Except the widely acknowledged influencing factors such as organic amendment, water regime during rice growing season, it was found that seasonal emission from late rice is higher than that from early rice, and the latter is higher than that from single rice, likely due to the difference in the water regimes before these rice seasons. A number of estimations have been made for the total CH_4 emission from Chinese rice fields, with more recent ones being around 7.6 Tg CH_4 $year^{-1}$.

Nitrous oxide (N_2O) emission from paddy fields in China has been measured on over 20 sites, with seasonal emissions ranging from 0.02 to 12.6 kg N ha^{-1}. Estimated annual emission ranged from 29 to 37 Gg N.

While emitting CH_4, paddy fields in China acted as a sink of atmospheric carbon dioxide (CO_2). Average soil organic carbon content of paddy fields increased by 2.5% from 1980 to 2007, which translates to a carbon sequestration of 74 Tg for the paddy fields nationwide. The sequestrated carbon equals 5.3% of the CH_4 emitted during the same time period in terms of global warming potential (GWP).

In summary, Chinese paddy fields emit CH_4 and N_2O at 190 and 9.8 Tg CO_2-eq year^{-1}, respectively, and sequestrate carbon at 10 Tg CO_2-eq year^{-1}. Thus the GWP of paddy fields is absolutely dominated by CH_4 emission.

Analysis of research stocktaking in the Paddy Rice Research Group of the Global Research Alliance on Agricultural Greenhouse Gases

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The Global Research Alliance on Agricultural Greenhouse Gases, which was launched in December 2009, brings countries together to find ways to grow more food without increasing GHG emissions (Global Research Alliance; Shafer et al., 2011). As an initial activity in the Alliance, research stocktaking was conducted within participating countries to identify current research activities, opportunities, gaps and areas of overlap. The results for the Paddy Rice Research Group are presented.

A detailed spreadsheet that captures information on each country's research projects and programmes in agricultural greenhouse gas emissions was prepared and distributed to each contact point of the Alliance member countries. The questions on the spreadsheet include research target, topic, outcome, structure, etc. as well as key equipment, facilities, and databases. As at 1 March 2011, 68 projects from 16 countries (China, Denmark, Ghana, Indonesia, Japan, Korea, Malaysia, Netherlands, Pakistan, Peru, Philippines, Russian Federation, Spain, Thailand, Uruguay and US) had been listed in the stocktake of the Paddy Rice Research Group.

Most of the research is being undertaken into irrigated rice production systems, with little on rain-fed production systems. The lack of data for rain-fed systems may cause difficulties when one tries to develop country specific emission factors. Projects focusing on methane accounted just over 50%, and the percentages for nitrous oxide and soil carbon sinks/sources were 30% and 20%, respectively. This result suggests that possible trade-off between different GHGs and the importance of evaluating the net global warming potential are well understood in many research projects.

There were two areas of research that predominated: GHG accounting/life cycle assessment and agronomy. While much smaller, the third focus for research was farming systems. In terms of research outcomes, the key primary outcomes were included: testing of mitigation, low greenhouse gas emitting varieties, improved national inventory and investigation of mitigation options. Most of the current research can be described as "applied" or "tactical" and is primarily funded from governments. The results indicate the general need for research progress on developing mitigation options and improving national inventories for GHG emissions from paddy fields in many countries.

The Paddy Rice Research Group of the Alliance will continue to compile databases on research projects, experts and literature related to GHG emissions from paddy fields in each member country. Those processes will be conducted through the contact point of each country. The Group also plans to develop and publish a manual of standardised measurement techniques for GHG emissions from paddy fields through identification of "good practice" and gaps in current methodology. As a plan for longer term action, it is discussing to develop a simple project protocol for evaluating promising mitigation options, such as water management practices, that would be undertaken in a number of rice producing countries.